KEC
van Kempen Engineering & Consultancy

SPIder Conference

“Quality of COTS products in Aerospace"

Methodology and lessons learned from aerospace projects

22 September

Ir. P. van Kempen, KEC

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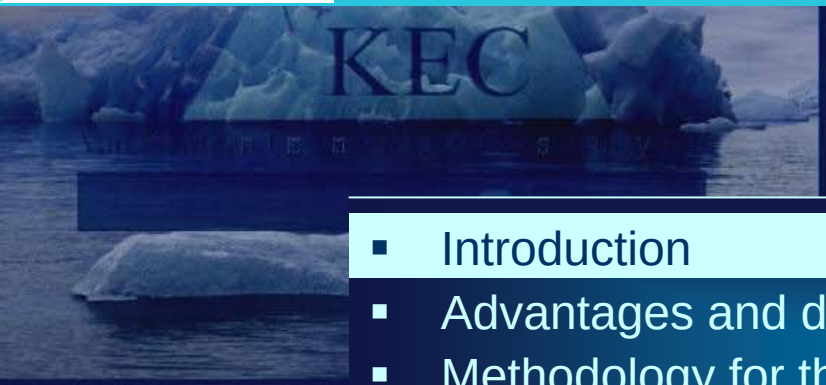

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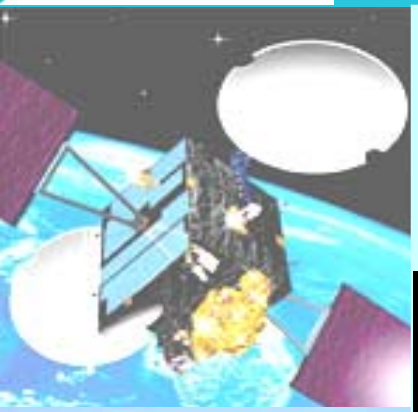
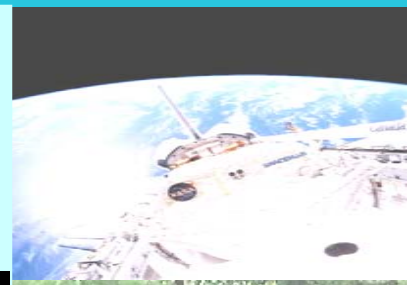
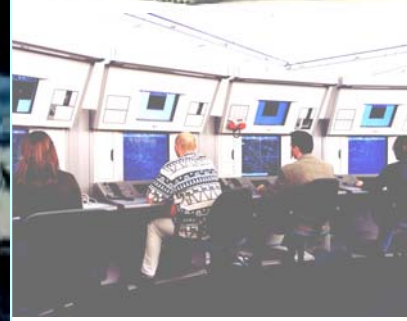
Leading in High-Tech







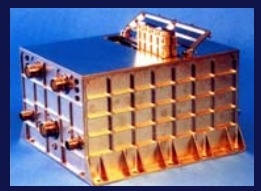



- MANAGEMENT & ORGANISATION
- BUSSINESS DEVELOPMENT
- SYSTEMS ENGINEERING

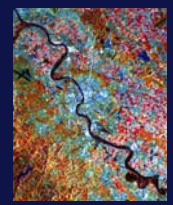
Introduction

KEC experience

- Aerospace & Defense, High-Tech markets
- Projects:
  - COTS based Mass Storage Device of the on-board computer of Space Station
  - Product Assurance & Safety Approach for the Use of COTS in Space
  - Software product quality requirements for a CNS/ATM system







The COTS advantages & disadvantages and the methodology for the use of COTS will be presented, based on the experience of the three projects

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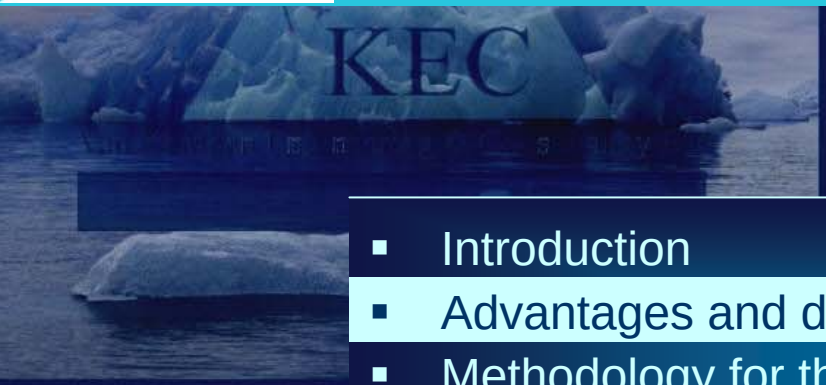

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Mass Storage Device

MSD Project Starting Points

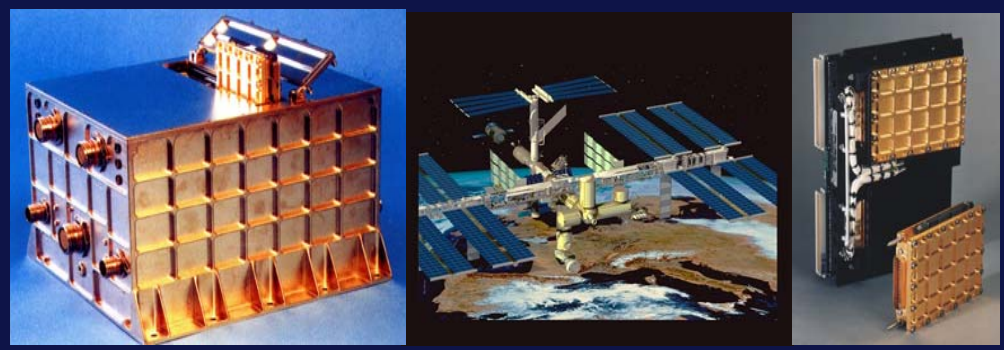
MSD starting point:

- Use COTS: commercial PCMCIA compatible 260Mb Winchester Disk Drives

Expected benefits:

- Possibility to easily implement higher capacity disks when available for the consumer market
- Low cost and short design phase

ESA award in 1999 for valuable European contribution to Space Station



The MSD is part of the on-board computers of the Russian and European segment of Space Station.

MSD Experience

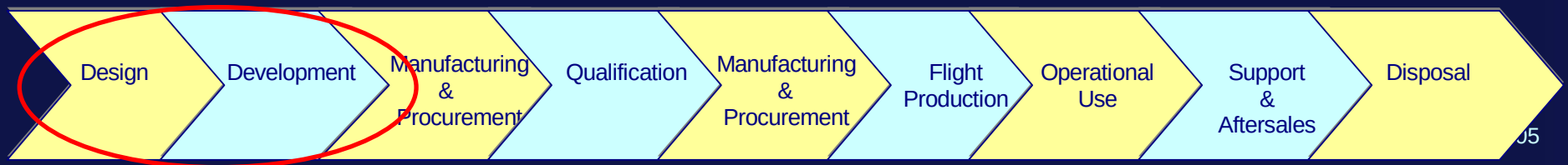
Advantages and disadvantages COTS / MSD Project

Advantages of COTS (in case COTS is used at a significant level)

- Many characteristics are known at the start of the project
- Test equipment can be designed in parallel
- Early definition of the main characteristics of the final flight baseline
- Limited design activities

Disadvantages of COTS

- Product manuals of COTS items do not cover all aspects of interest to space systems designers
- Description of COTS items in product manuals not accurate enough
- Large manufacturing tolerances may result in the requirement for screening



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MSD Experience

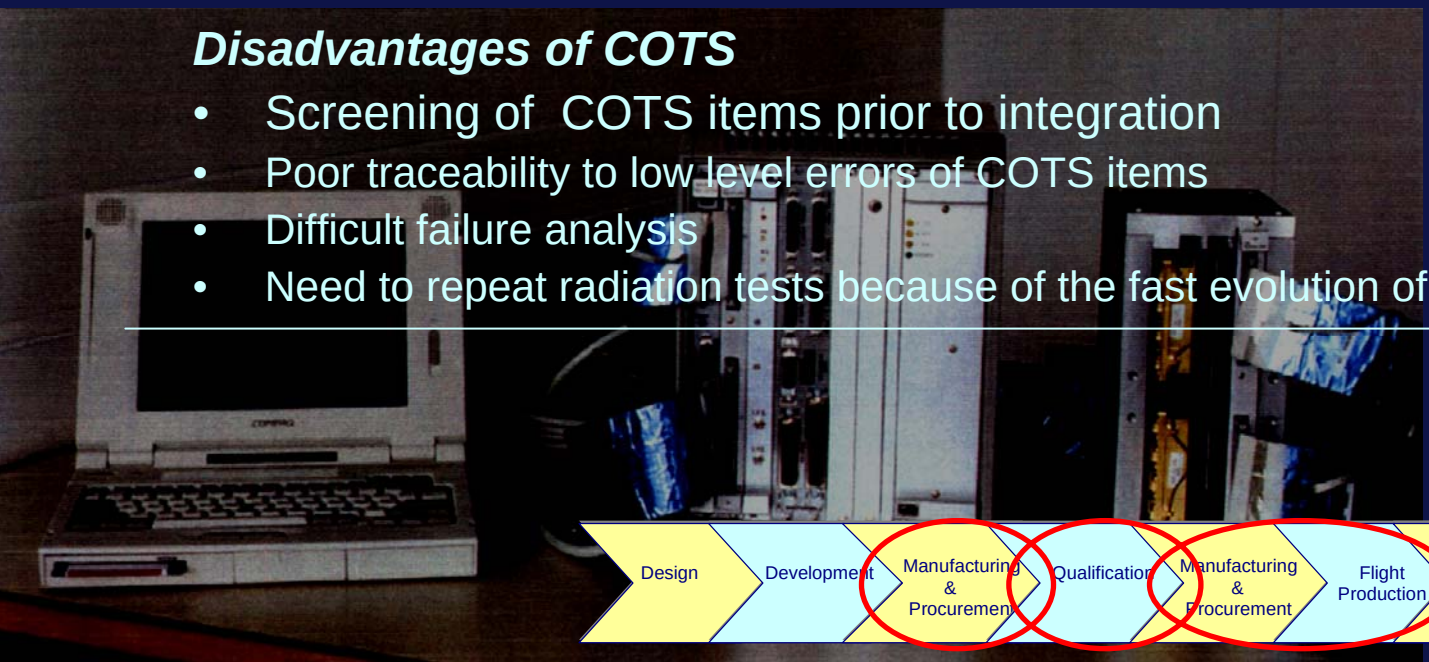
Advantages and disadvantages COTS / MSD Project

Advantages of COTS (in case COTS is used at a significant level)

- No specific manufacturing conditions or tools are required
- Relatively complex parts/functions can be integrated relatively easy
- Easy testing/test equipment
- Possibility to use low cost, commercial test equipment (that can be used from the beginning of the project)

Disadvantages of COTS

- Screening of COTS items prior to integration
- Poor traceability to low level errors of COTS items
- Difficult failure analysis
- Need to repeat radiation tests because of the fast evolution of COTS electronics



MSD Experience

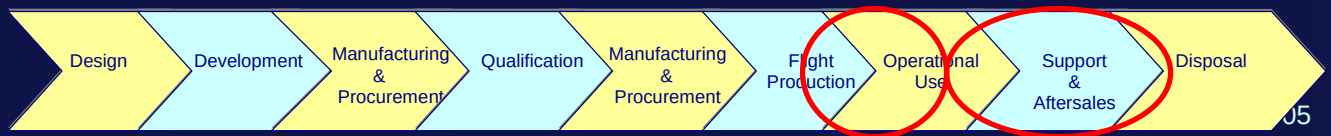
Advantages and disadvantages COTS / MSD Project

Advantages of COTS (in case COTS is used at a significant level)

- Possibility to use relatively cheap and easy available Ground Support Equipment (GSE)
  - MSD: Ground Support Tool can be used to format and install S/W in an office environment
  - Low cost MSD + GST can be used for training
- Possibility to integrate new/improved COTS modules relatively easy

Disadvantages of COTS

- Short product life cycle of COTS items
- Poor support from suppliers in case of anomalies



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Summary MSD Experience

Overview of COTS related problems

- Product Manual
- Product Characteristics
- Failure analysis and traceability
- Short lifecycle
- Poor support
- Supplier related

Overview of COTS related benefits

- Insert latest technology
- Time to market
- Lower cost
- Design of test equipment in parallel
- Early definition of final baseline

The MSD project was performed without having a real methodology for the use of COTS

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KEC and Alenia have initiated a new ECSS standard

New PA&S Methodology for the use of COTS in Space

Development and validation of a new PA&S standard

PA&S (Product Assurance and Safety) =
QA (quality assurance) +
R (reliability) +
A (availability) +
M (maintainability) +
S (safety)

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

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Methodology for the use of COTS

Starting points

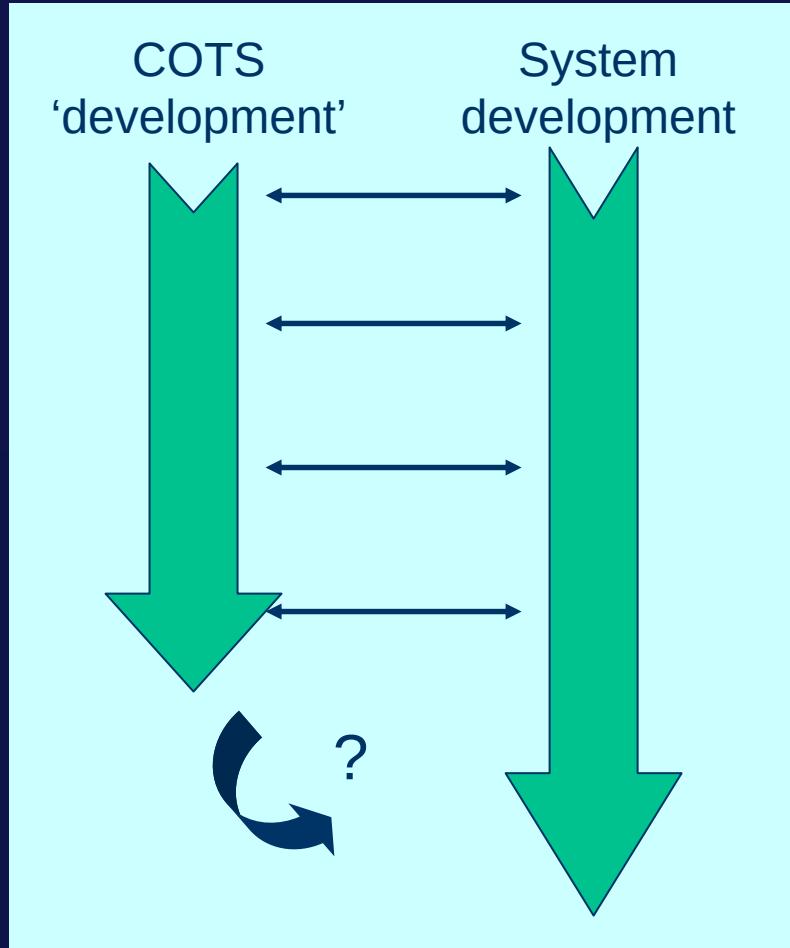
- System requirements do not change when COTS is used
- Measures are typically introduced to manage COTS related risks
- Benefit from COTS advantages
- There is a strong link between management, engineering and quality -> need for quality engineering
- Processes of COTS suppliers are unknown or can not be controlled

For COTS quality management needs to focus on *product* quality

There is a strong link between the lifecycles of the COTS item and the system

Methodology

- Make or buy evaluation
- Excluded COTS categories
- Market survey
- COTS item requirements
- Selection
- Procurement and upgrading requirements
- System compensation measures
- COTS qualification



Typically a risk and economic analysis support the decision whether or not to use COTS

Criticality analysis tools can be developed for the use of COTS

Criticality Analysis
PA&S Approach for the Use of COTS in Space

COTS Item Name / Part Number : WDD

COTS Item Manufacturer : Integral (US)

No. :	Bad performance at edges of specifications or ´combined´ environmental stress	
34	*Severity*: 3-4	*Likelihood*: 3

Potential Risk Reduction Measures:	*Feasibility*	*Cost*
Perform screening to select best items	3	3
Perform worst case analyses	2	2
Perform worst case, combined tests	3	4

Notes: Due to manufacturing tolerances COTS items may perform badly at the edges of specifications. Moreover, COTS items may perform badly in cased of combined environmental stress (e.g. bad performance when vibrated at low temperatures).

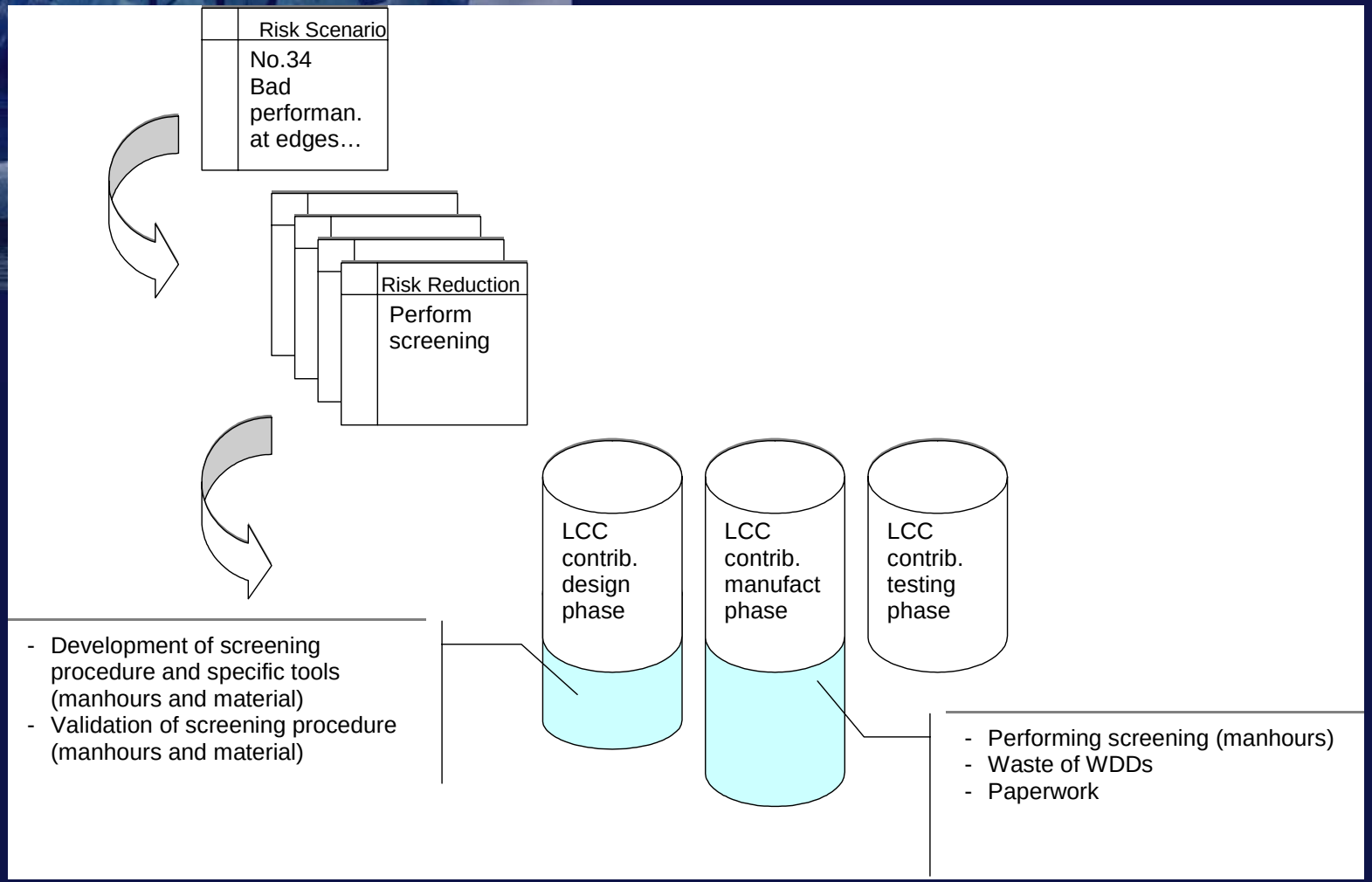
Economic considerations

Type and Title of Risk Reduction Measures:	*Life cylcle phase & type of costs*								
Corresponding Activities:	*D&D*			*M*			*T*		
	L	*M*	*F*	*L*	*M*	*F*	*L*	*M*	*F*
PA: Perform screening to select best items									
Development of screening procedure	D1 D2 D3	D2	D2						
Validation of screening procedure	V1 V2 V3	V1 V2	V1 V2						
Implementation (performing) screening				I1	I1 I2	I1			

Legenda: Feasibility : 1 high, 5 low, Cost : 1 low, 5 high
Severity: 1 low, 5 high, Likelihood: 1 low, 5 high
Lifecylce phase: D&D (Design & Development), M (Manufacturing), T (Test)
Type of costs: L (Labour), M (Materials), F (Facilities)
Type of risk reduction measure: PA, E (Engineering), M (Manufacturing), T (Test)
Dn, Vn, In: cost contributors

Source: KEC 2005

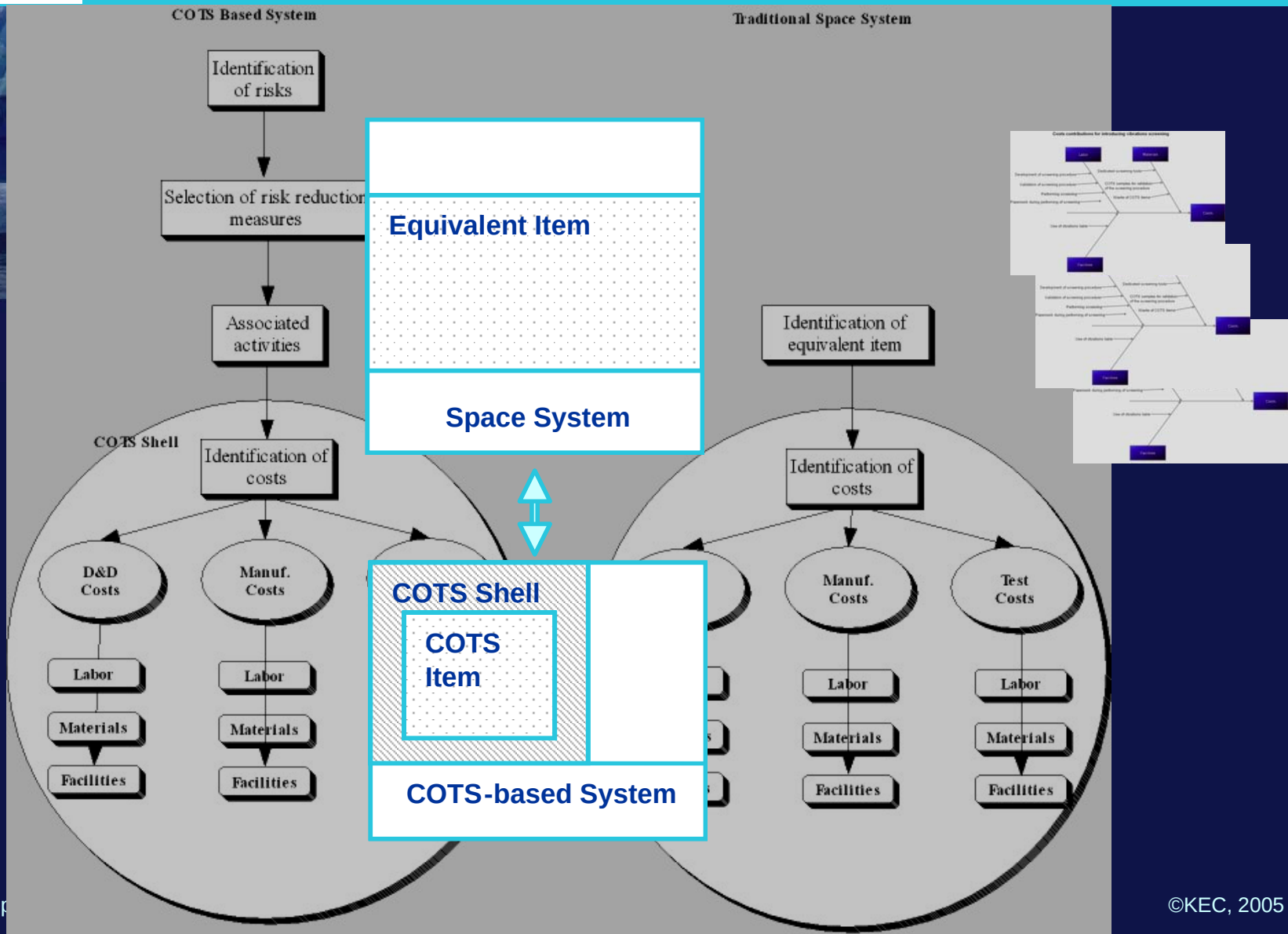
Risk scenario's result in lifecycle costs



Source: KEC 2005

Models can be developed to make an economical analysis

Source: KEC 2005



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Measures MSD

Identified risk areas at the start of the project

- Radiation sensitivity of WDD
- Non qualified parts and materials of the WDD

Corresponding measures

- Latch-up protection
- Radiation tests
- Hermetic enclosure
- Black box approach

Measures MSD project – during the project

- Agreements with suppliers w.r.t. chipset changes and last buy possibilities
- NDA with suppliers w.r.t. EDAC
- Screening (voltage, temperature, vibrations)
- Adaptation (COG, ruggedizing, connector locking)
- Qualification COTS item

For a long time a too rigid black box approach was applied during the project. As a result various COTS related problems had to be solved during expensive phases of the project

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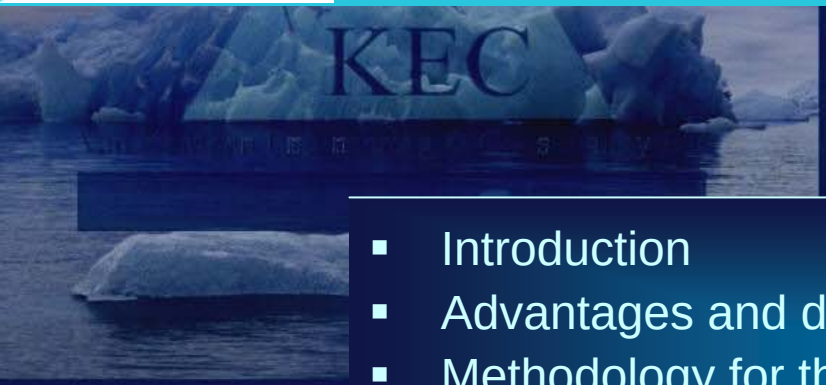

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Software quality - Eurocontrol

Eurocontrol

- Software quality requirements, incl. Metrics (Q-model)
- Software architecture
  - Long term maintainability, sustainability, reliability and safety
- Assessment possibilities during complete lifecycle

Similar requirements are also applicable for other high end ICT applications, e.g. remote sensing

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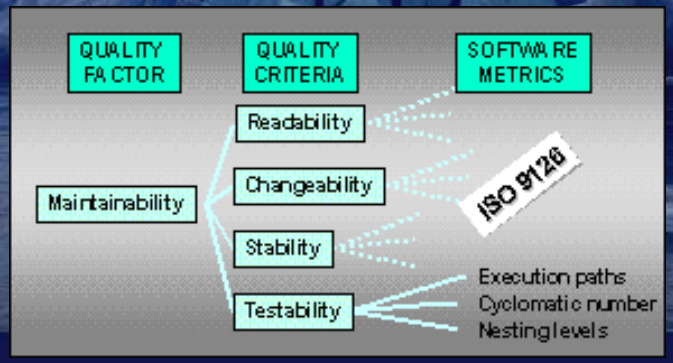
There a different types of quality

Three types of quality

- Quality of conformance

- Quality of design
- Quality of performance

A quality model can be used to measure software product quality



Some quality factors can be found in the ISO9126 Std.

Quality Characteristic

Quality Sub-Characteristics

Metrics
(attribute, measurement method & scale)

Source: KEC 2001

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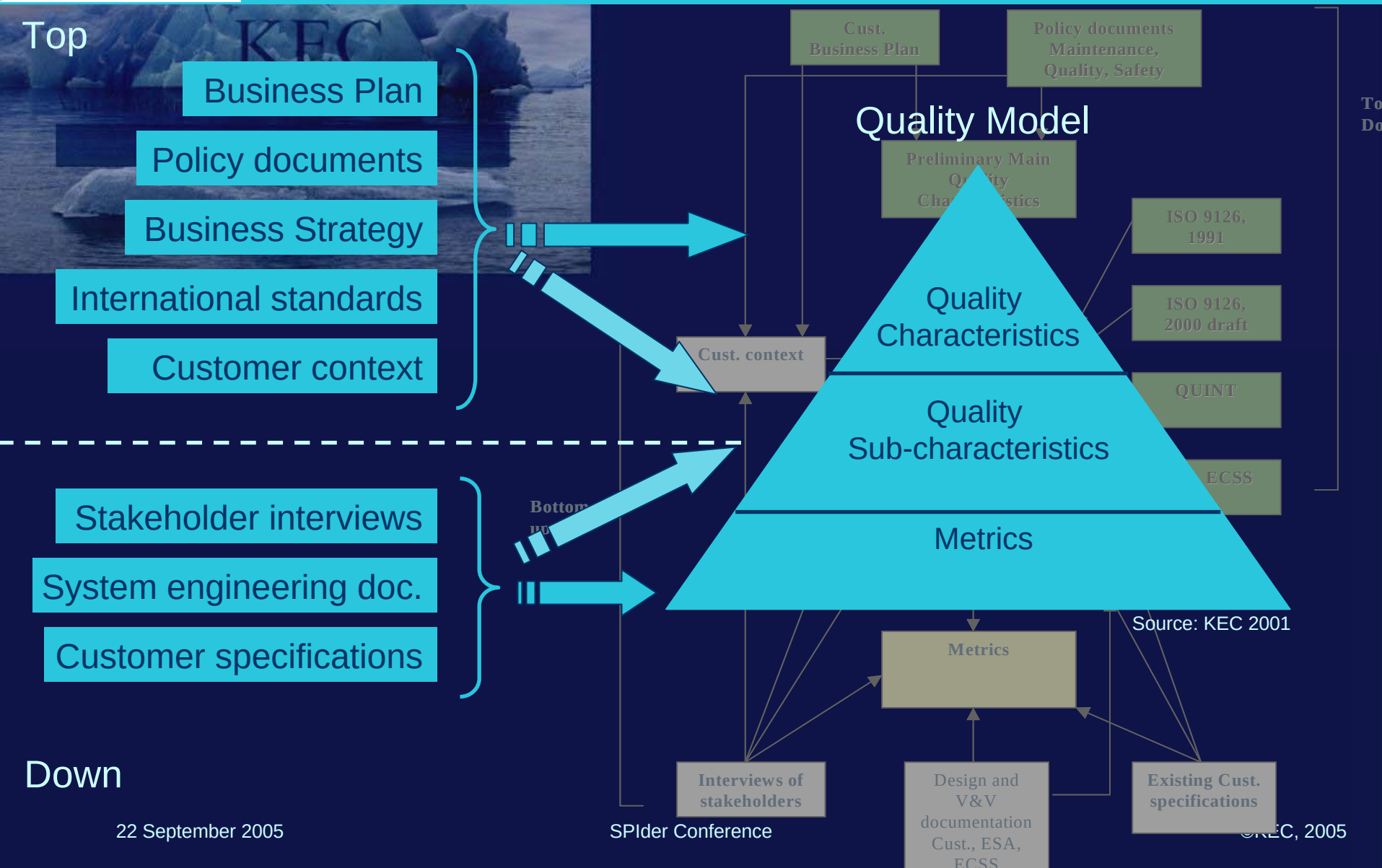
Design of a quality model is done according to a top down and bottom up approach

Top

- Business Plan
- Policy documents
- Business Strategy
- International standards
- Customer context

Down

- Stakeholder interviews
- System engineering doc.
- Customer specifications



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Quality specification

- Quality specification =
  - Quality characteristics +
  - Quality sub-characteristics +
  - Metrics

Example:

The maintainability of software is served by good analysability, which in turn requires proper diagnostic function support (Df). 0.6<Df<1 shall be established/demonstrated at the TRR of the acceptance test.

But what is good and what is not acceptable?

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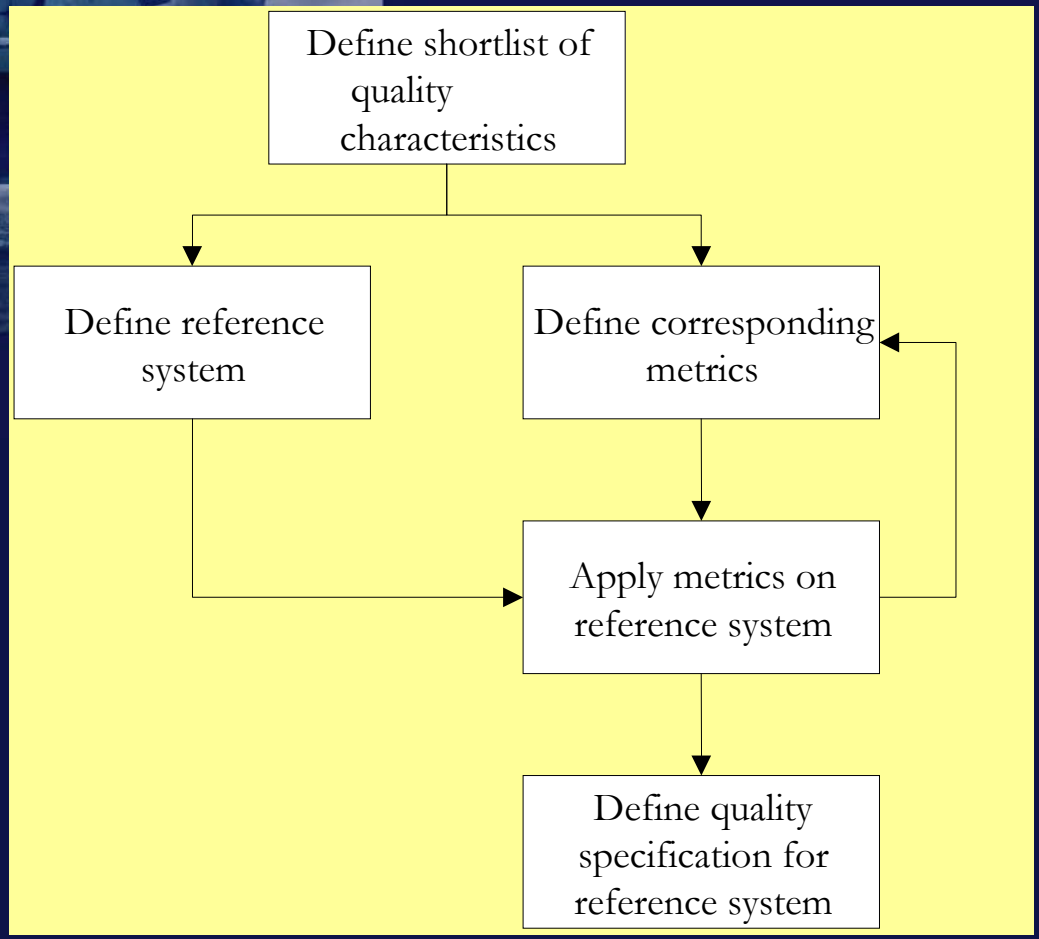
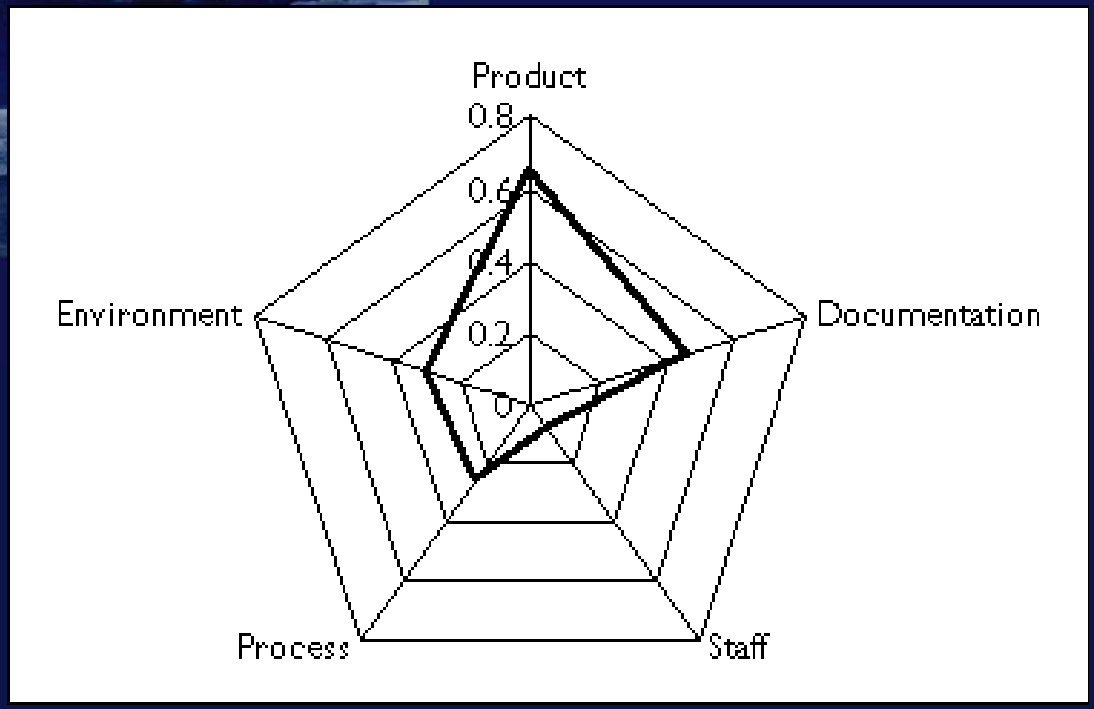
Metrics definition



Source: KEC 2001

Reliable quantification is based on experience

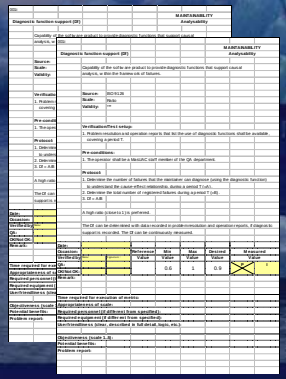
There are various aspects that affect software quality



Software complexity drivers

Some metrics can be conflicting (e.g. regarding analysability and performance)

Metric definition



Metrics shall be verified regarding:

- Reliability
- Safety
- Repeatability
- Reproducibility
- Availability
- Objectiveness
- Accuracy
- Meaningfulness
- Nature (P/I)
- Costs
- Potential benefits

A limited number of metrics shall be used throughout product lifecycles

(costs, meaningfulness)

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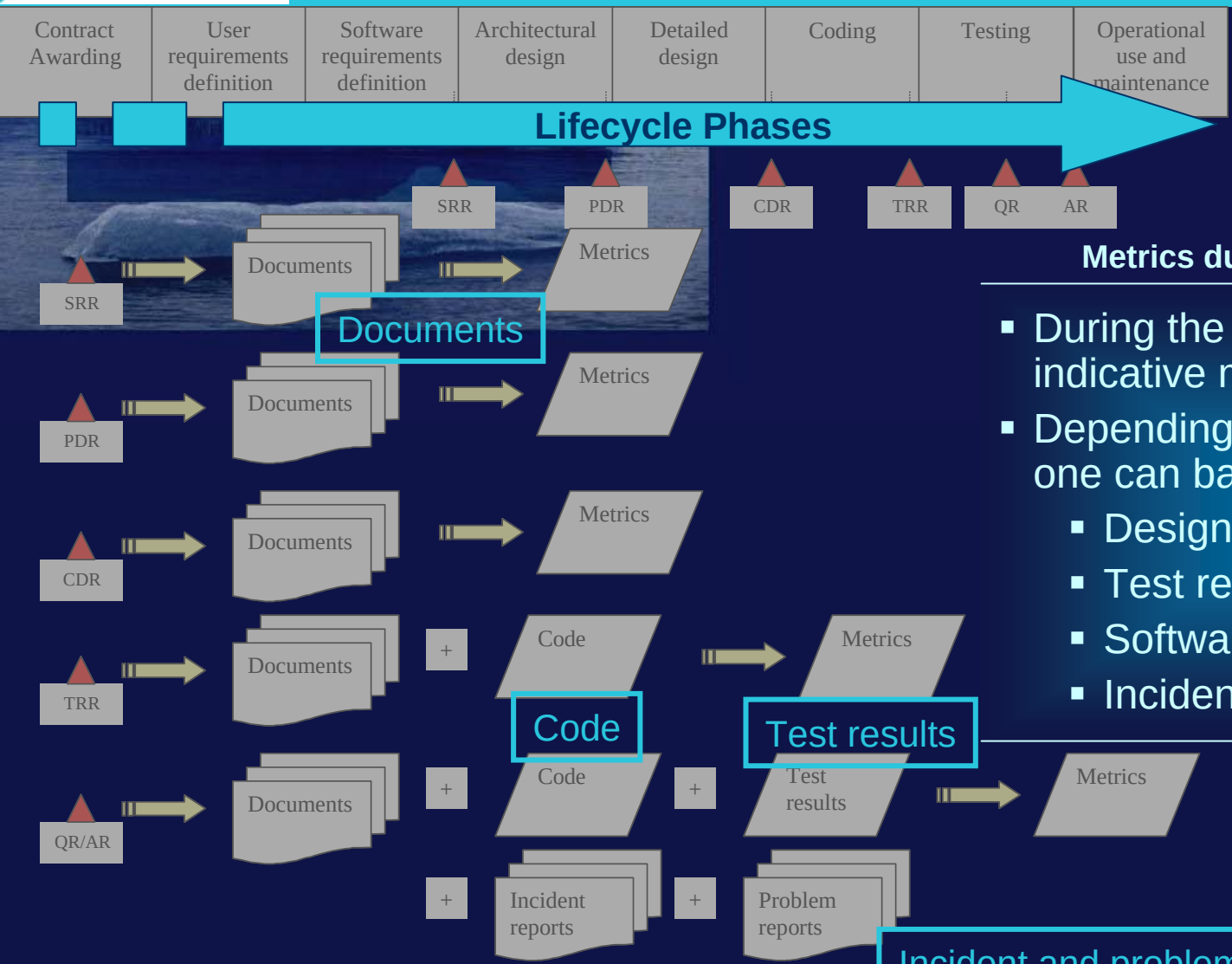
Automatic tools for code analysis

- Tools evaluated:
  - Logiscope (Telelogic)
  - McCabe IQ (McCabe)
  - Sema Audit & Skipper
  - QA (C and C++) (Programming Research)
  - Purify (Rational)
- Characteristics:
  - COTS
  - Static analyser (structure and rule checker)
  - Dynamic analysis (e.g. test coverage)

Metrics during the lifecycle



Metrics during the lifecycle

- During the lifecycle predictive or indicative metrics can be used
- Depending on the lifecycle phase one can base metrics on:
  - Design documentation
  - Test reports
  - Software code
  - Incident and problem reports

Software product quality wrap up

Main recommendations software quality

- A quality model can be used to to predict and measure software quality
- A top down and bottom up approach can be used to design a quality model
- Limit the number of metrics (cost/benefit)
- Tools can be used for automatic code analysis
- Experience shall be reflected in metrics
- Use of metrics shall be planned throughout the lifecycle

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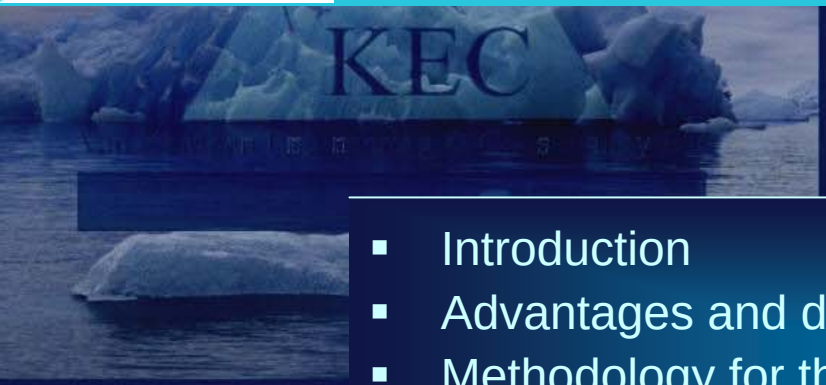

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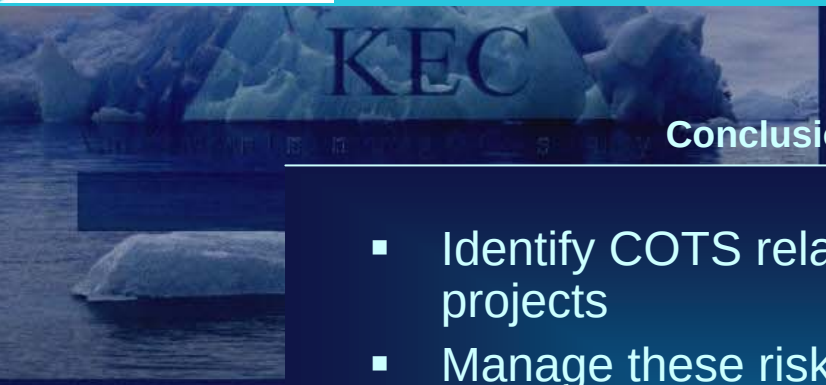

Conclusion w.r.t. the use of COTS

- Identify COTS related risks at an early stage of projects
- Manage these risks either at COTS item or system level
- Don’t apply a too rigid black box approach (w.r.t. understanding failure mechanisms)
- Analyse the complete lifecycle and associated costs
- A Quality Model with metrics can be used to predict and measure software quality

- There is limited experience with the use of COTS; Community of Practice to share experiences

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Contact information

KEC
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Ir. P. (Paul) van Kempen
Managing Director

Charles Stulemeijerweg 7, 5026 RS Tilburg, The Netherlands
P.O. Box 2226, 5001 CE Tilburg, The Netherlands
Tel. (+31) 13 4550044, Fax (+31) 13 4550450
E-mail: pvk@kec.nl Internet: www.kec.nl